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Effect of cropping system on some genetic parameters in soybean [*Glycine max* (L.) Merrill]

V. K. Sood and O. P. Sood

Department of Plant Breeding & Genetics, Himachal Pradesh Krishi Vishvavidyalaya, Palampur 176 062

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Abstract

Genetic parameters were assessed in 14 diverse genotypes of soybean grown in sole crop and as inter crop with maize. Cropping system effects were significant for all the traits, except seeds/pod. Cropping systems × genotype interaction was significant for all the traits except branches/plant and 100-seed weight. Both phenotypic and genotypic coefficient of variation were higher for plant height, branches/plant and seed yield in intercropping than sole crop. Genetic advance was comparable for most of the traits under both the cropping systems. The correlation coefficients, direct and indirect effects were found to differ both in nature and magnitude in sole crop and intercropping. Plant height and days to maturity showed no association with grain yield indicating the possibility to select for high yielding genotypes irrespective of plant height and maturity under intercropping. Pods/plant followed by seeds/pod and branches/plant with higher days to flowering were important to improve seed yield under intercropping. Pods/plant followed by higher days to flowering and longer heights with lesser days to maturity were important to improve seed yield under sole crop. Genotype P8 (Himso 400 × Punjab-1) was high yielding and synchronous in maturity with maize. Separate breeding programmes are required to be undertaken for each cropping system.

Key words: Soybean, intercropping, sole crop, genetic parameters

Introduction

Development of cultivars suitable for intercropping has received no priority in Indian soybean-breeding programme, because soybean breeders have, to date, preferred to select only for sole crop with the assumption that correlated improvement will occur in intercrop. Hence, varieties developed for sole crop are also being cultivated under intercropping. However, significant genotype × cropping system interaction for various traits have been reported in soybean [1-3]. Most of the information on genetic variability and other genetic parameters in soybean is available only under sole crop and very limited information about the nature and magnitude of alterations when intercropped with maize. To make a rational decision on whether a special selection programme is necessary for improving soybean grain yield in intercrop, information is needed on the effect of intercropping on the expression of genetic parameters. Hence, the present study was initiated to determine how cropping systems affect the expression of genetic variability, nature and magnitude of association of different traits, and direct and indirect effect of various traits toward seed yield.

Materials and methods

Fourteen diverse genotypes of soybean were grown in a randomized block design with three replications under two cropping systems viz., sole crop and intercropping with maize. In sole crop, the plots consisted of 4 rows of soybean 3m long and 30 cm apart in each replication. Under intercropping, treatments were identical except that maize (Parvati, a locally recommended variety) and soybean were grown in alternate rows 60 cm apart. The plants of soybean and maize were spaced 5 and 15 cm apart, respectively, to maintain the same plant densities of both crops under different cropping systems. Recommended package of practices were followed to raise both the crops. Observations were recorded on ten randomly selected plants/replication from each genotype for days to flowering and maturity, plant height (cm), branches/plant, pods/plant, seeds/pod, 100-seed weight (g) and seed yield (kg/ha). The data for each trait were subjected to analysis of variance, genotypic and phenotypic coefficient of variability, heritability and expected genetic advance [4]. The phenotypic correlation coefficient for all the character combinations were computed according to Al-Jibouri *et at.* [5]. The correlation coefficient were partitioned into components of direct and indirect effects by path-coefficient analysis as suggested by Dewey and Lu [6].

Results and discussion

Cropping system effects were significant for all the

traits except seeds/pod, whereas interaction of cropping systems with genotype were also significant for all the traits except branches/plant and 100-seed weight (Table 1). The presence of strong genotype x system yield under intercropping. Heritability estimates were comparable for rest of the traits under both the cropping systems. Genetic advance (GA) was high for plant height and low for pods/plant under intercropping.

Table 1. Pooled analysis of variance over cropping patterns for different traits in soybean

Source	df	Mean sum of squares							
		Days to 50% flowering	Days to maturity	Plant height	Branches/ plant	Pods/ plant	Seeds/ pod	100-seed weight	Seed yield
Replications	2	1.45	1.00	48.75	5.62	131.32	0.008	0.48	2536.0*
Cropping systems	1	1276.03*	693.3*	171.7.0*	65.67*	24544.0*	0.211	51.02*	3246864.0*
Genotypes	14	912.9*	98.79*	868.8*	3.10*	701.26*	0.053*	55.71*	42309.3*
Cropping system × genotypes	14	6.93*	14.18*	128.96*	1.83	279.72*	0.356*	1.27	12497.3*
Error	56	1.09	1.05	66.65	1.02	77.94	0.024	0.76	5116.2

*P<0.5

interaction for seed yield and its components suggested that it may be necessary to test and choose different varieties for each system. The range values were higher for days to flowering, branches/plant, pods/plant and seed yield/plant under sole cropping than under intercropping (Table 2). The range of values was higher for days to maturity, plant height and 100-seed weight in intercropping than under sole crop. There was no difference in the range value for seeds/pod under both cropping systems. Plant height, branches/plant, pods/plant and seed yield were higher under sole crop (Table 2). However, days to flowering and maturity were higher under intercropping. The performance of the remaining characters was similar under both cropping systems. Sharma and Mehta [7] reported decrease in branches/plant, pods/plant and seed yield under intercropping. Both phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values were higher for plant height, branchcs/plant and seed yield in intercropping than sole crop. PCV and GCV values were comparable for the remaining traits under both cropping systems. Heritability (H) estimates were higher for branches/plant, seeds/pod and seed Genetic advance was comparable for the remaining traits under both the cropping systems. High H coupled with high GA was observed for seed yield under intercropping. Moderate H and moderate GA for days to 50% flowering, plant height and pods/plant under both the cropping systems indicated possible improvement of these traits through selection.

Correlation and path coefficient analysis (Table 3) has, revealed interesting impact of intercropping in influencing the covariances among traits and hence correlation values showing synergistic effect of intercropping influencing trait expression in soybeans leading to better associations among traits under intercropping for making indirect selection to yield through component traits. These results suggest different selection parameter under intercropping system for seed yield improvement in soybean. Under intercropping pods/plant, branches/plant, seeds/pod and days to flowering showed considerable increase in the magnitudes of correlation with yield in comparison to sole crop. Path analysis also showed that pods/plant and 100-seed weight contributed with high indirect effect

Table 2. Range, mean, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability (H) and genetic advance (GA) for different traits in soybean under two cropping systems

Character	Range		Mean		PCV(%)		GCV(%)		H		GA	
	M	I	M	I	M	I	M	I	M	I	M	I
Days to 50% flowering	36.3-71.7	43.0-77.6	55.0	62.4	22.28	20.11	22.14	20.10	98.7	99.8	24.96	25.80
Days to maturity	113-125.7	116.7-131.0	117.3	122.7	3.14	4.11	2.95	4.07	88.6	97.9	6.72	10.18
Plant height	72.0-111.3	56.3-119.7	87.0	78.6	14.28	20.77	11.34	17.56	63.0	71.5	16.15	24.05
Branches/plant	3.0-5.9	1.2-4.07	4.3	2.6	30.66	43.43	13.57	30.30	19.6	48.7	0.53	1.14
Pods/plant	27.0-84.7	13.67-47.0	65.4	33.4	27.67	30.39	21.92	24.91	62.8	67.2	23.40	14.06
Seeds/pod	2.17-2.67	1.98-2.45	2.42	2.33	7.76	7.11	2.09	4.38	7.2	38.0	0.03	0.13
100-seed weight	8.99-17.92	10.48-20.17	14.00	15.43	21.73	21.27	21.04	20.31	93.8	91.2	5.87	6.17
Seed yield	330.0-743.0	93.3-320.0	599.9	232.0	22.62	35.22	15.88	32.77	49.3	86.5	137.8	145.72

M = Monoculture
I = Intercropping

through seeds/pod. The direct effect of seeds/pod was also of high magnitude alongwith branches/plant. Days to flowering had high direct effect and high indirect effect through branches/plant. The cot-relation and direct and indirect effect of plant height and days to maturity showed to be independent with grain yield thus making selection of dwarf or tall or early or late maturing types without affecting grain yield under intercropping. Thus, under intercropping selection parameters should give highest weightage to pods/plant followed by giving equal weightage to seeds/pod and branches/plant with higher days to flowering. In contrast to intercropping, in sole crop only pods/plant showed high correlation with yield as well as high direct positive effect (Table 3). 100-seed weight also showed comparatively high correlation value and high indirect effects through pods/plant, plant height and days to maturity. Direct effects of days to flowering and plant height were very high though correlation did not reflect it. In contrast to intercropping, days to maturity showed

Table 3. Direct and indirect effects of important traits on seed yield in soybean under two cropping systems

Characters	Effect via:	Days to flowering	Days to maturity	Plant height	Branches/ plant	Pods/plant	Seeds/pod	100-seed weight	Correlation with seed yield
Days to flowering	M	**1.983**	−0.571	−1.031	−0.142	−0.412	−0.032	−0.067	−0.271
	I	**0.446**	−0.117	−0.351	0.749	−0.288	0.085	−0.051	−0.474
Days to maturity	M	0.999	**−1.135**	0.396	−0.277	−0.247	−0.022	−0.045	−0.330
	I	0.175	**−0.298**	−0.080	0.407	−0.036	−0.136	−0.006	0.025
Plant height	M	−1.229	−0.270	**1.663**	−0.123	0.076	−0.049	0.039	0.107
	I	−0.329	0.050	**0.476**	−0.564	0.106	−0.012	0.064	−0.208
Branches/plant	M	0.500	−0.558	0.365	**−0.563**	0.348	−0.009	−0.007	0.075
	I	0.384	−0.139	−0.309	**0.869**	−0.084	−0.065	−0.077	0.580
Pods/plant	M	−0.754	0.259	0.117	−0.181	**1.083**	0.090	0.061	0.674
	I	0.211	−0.018	−0.083	0.120	**−0.608**	1.124	0.013	0.760
Seeds/pod	M	−0.704	0.274	−0.915	0.058	1.090	**0.089**	0.074	−0.034
	I	0.035	0.037	−0.005	−0.052	−0.630	**1.085**	0.054	0.523
100-seed weight	M	−0.934	0.356	0.455	0.028	0.467	0.046	**0.142**	0.562
	I	−0.219	0.018	0.298	−0.653	−0.077	0.567	**0.103**	0.037

M = Monoculture
I = Intercropping

Table 4. Mean values of different genotypes for seed yield and its contributing traits in soybean under intercropping system

S.No.	Genotype	Days to flowering	Days to maturity	Plant height	Branches/ plant	Pods/ plant	Seeds/ pod	100-seed weight	Seed yield (kg/ha)
1.	P6-1 (Cooker Stuart × Lee)	77	129	78	2.87	47	2.44	16.85	303
2.	P8-1-1-1 (Himso 473 × Punjab-1)	62	119	74	1.33	27	2.23	13.75	93
3.	P8-2 (PK 739 × Bragg)	74	127	73	3.07	44	2.40	15.62	313
4.	P13-4 (Himso 59 × Himso 400)	62	118	66	2.40	32	2.29	17.21	253
5.	P21-2-1 (Himso 473 × Lee)	43	127	91	1.20	21	2.21	19.66	140
6.	P1-1 (JS 78-53 × Punjab-1)	69	128	56	3.80	38	2.39	10.83	243
7.	P2-1-1 (Punjab-1 × DS 74-22)	77	127	72	3.07	40	2.37	15.44	296
8.	P3-2 (Himso 473 × Punjab-1)	43	118	90	1.20	28	2.33	16.33	250
9.	P3-3 (Himso 473 × Punjab-1)	43	117	120	2.07	35	2.31	18.36	243
10.	P4-1 (Uniculm × Bragg)	43	125	95	1.67	35	2.52	20.17	136
11.	P4-2-1 (Punjab-1 × DS74-22)	73	125	79	3.20	40	2.44	17.87	320
12.	P8 (Himso 400 × Punjab-1)	71	118	72	2.80	43	2.45	12.10	320
13.	P45-1-1 (Lee × Himso 308)	63	118	72	2.87	30	2.33	18.21	296
14.	Himso 558	62	115	71	2.47	26	2.35	12.93	113
	CD at 5%	0.8	2.3	NS	0.2	9.3	0.09	0.93	80

high direct negative effect indicating the possibility of selecting early genotypes with high yield. Correlation showed branches/plant to be independent and even has negative effect on yield under sole crop in contrast to intercropping. Thus in sole crop, selection parameters should include pods/plant followed by higher days to flowering and longer heights with lesser days to maturity. It is interesting to note that the association of pods/plant is not influenced by the cropping system though under sole crop its direct effect on yield is also positive while in intercropping it is negative but compensated by high direct effect through seeds/pod (Table 3).

Genotypes P8 (Himso 400 × Punjab-1), P8-2 (PK 739 × Bragg), P6-1 (Cocker Stuart × Lee)) and P2-1-1 (Punjab-1 × DS74-22) performed better under intercropping. High yield of these genotypes was due to high mean values of component characters like pods/plant, seeds/pod, branches/plant and days to flowering (Table 4). Correlation and path coefficient analysis indicated the importance of these component characters in contributing towards seed yield and therefore selection for these component characters should be given weightage for improving seed yield in intercropping. Genotypes P8-2 (PK 739 × Bragg), P6-1 (Cocker Stuart × Lee) and P2-1-1 (Punjab-1 × DS74-22) were late in maturity as compared to maize. Only one genotype P8 (Himso 400 × Punjab-1) was having synchrony in maturity with maize and yielded 320kg/ha as a bonus yield of soybean without any reduction in yield of maize cultivar.

High positive genotypic correlation between two cropping systems for days to flowering, days to maturity plant height and 100-seed weight (Table 5) indicated the absence of genotype x cropping system interaction for these traits and thus there is no need for separate breeding programme to improve these traits. However for seed yield and its components such as branches/plant, pods/plant and sees/pod, though correlations were positive but of lower magnitude. Under such circumstances if genotype x cropping system interaction is also present for the traits, separate breeding programmes to improve these traits are required to be undertaken. The results are similar to those obtained by Davic and Gracia [8] for commonbean-maize and Sharma *et al.* [9] for soybean-maize system and thus justified separate breeding programme for each cropping system.

Table 5. Genotypic correlations (rg) between cropping systems

Trait	Genotypic coffelations (rg)
Days to flowering	0.98
Days to maturity	0.79
Plant height	0.77
Branches/plant	0.26
Pods/plant	0.50
Seeds/pod	0.19
100-seed weight	0.96
Seed yield	0.58

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